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## REMOVAL OF HAZARDOUS METALS FROM DRINKING WATER BY APPLICATION OF COMPLEXING WITH EDTA AND ANION EXCHANGE RESIN

In many places of the world, there are sources of fresh water supplies polluted with toxic metals. The conventional methods of their removal do not diminish metal concentration to allowable level. Though application of ion exchange method makes it possible to reach the required standard, the process proves to be expensive because it is difficult to achieve the required value of the selectivity coefficient of the toxic metal ions due to the presence of the common ions. Recently, a research work to overcome this difficulty was started. It was discovered that due to complexing of some toxic metals by EDTA the value of the selective coefficient of the toxic metal ions can be higher than that of common ions.

In this paper, the system of selective removal of lead and cadmium drinking water will be discussed in detail.

### 1. INTRODUCTION

One of the current problems in water and wastewater treatment is removal of low concentration of toxic metals. Heavy metals present in wastewaters are toxic pollutants that can affect man, animals, aquatic life and can even disrupt secondary sewage treatment facilities if discharged to sanitary sewers [1]. Recent studies on cadmium and lead have been focused on the impact of trace amounts of these heavy metals on man. The maximum allowable level of these metals in municipal water is quite low. Cadmium, a cumulative poison, can be a cause of some serious cardiovascular diseases.

Municipal waters should not exceed the concentration of  $0.01 \text{ mg of Cd/dm}^3$  if cumulative toxicity is to be prevented [2]. This metal is especially dangerous because it may act in synergism with other toxic agents like zinc and cyanide. Lead concentration in municipal water should not exceed  $0.1 \text{ mg/dm}^3$ . Although, in its elemental form, lead is not the main toxicant,

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its permanent supplying to human organism may have harmful effect. The salts of lead show substantial toxicity. Its carbonate arsenate and acetate are very toxic.

The techniques of metal ion removal from aqueous solution can be distinguished as follows:

1. Chemical precipitation of insoluble salts in the form of oxides or hydroxides.
2. Reverse osmosis.
3. Electro-osmosis.
4. Solvent extraction.
5. Ion exchange.

Of these techniques, ion exchange appears advantageous when removal, concentration, and immobilization of trace heavy metals are taken into account [3].

The difficulty in applying ion exchange lies in the fact that it is not easy to find such a selective resin which could selectively remove only the required toxic ions, and therefore the resin capacity would not be exhausted by the common ions. One of the possible ways to overcome this drawback is the bonding of ions of toxic metal with a complexing agent to form a new anion which has higher affinity towards the ion exchange resin. Rough evaluation of data on complexing chemistry allows us to conclude that EDTA is likely to form complexes with cadmium and lead which have higher affinity to anion resins than the common ions present in potable water. It was therefore decided to add EDTA to potable water in such an amount as to obtain a stoichiometric composition of this complexone and cadmium and lead. Experiments were performed with Amberlite IRA 402.

## 2. RESEARCH OBJECTIVE

The purpose of the work is to determine the parameters at which complexed toxic ions of cadmium and lead can be removed selectively by anion exchange resin.

## 3. EXPERIMENTAL

The first experimental series was carried out on cadmium. The experiments were performed on laboratory scale under dynamic conditions, using strong base anion exchange resin – Amberlite IRA 402 in its standard chloride form. To change the chloride form into the hydroxide one, the resin was treated with 4% NaOH. After rinsing with distilled water, 1% solution of HCl had been passed through the column at the rate of 4 cm<sup>3</sup>/min until the reaction changed from a basic to acid. The resin was then rinsed with distilled water. Artificially prepared wastewater was used in the experiments. It contained two different cadmium concentrations (10 and 100 mg/dm<sup>3</sup>) which were in stoichiometric proportion to the respective doses of EDTA. Hence, the complex solution formed contained ions of cadmium and EDTA. Figure 1 shows the diagram of the working apparatus. Special attention is paid to the upright position of the column which is designed in such a way that air does not get at the resin bed. The peristaltic pump, type PPI-05A, pumps the prepared solution from the container through the rubber tube to glass columns of uniform diameters but different heights (30 cm, 40 cm and 60 cm). Effluent

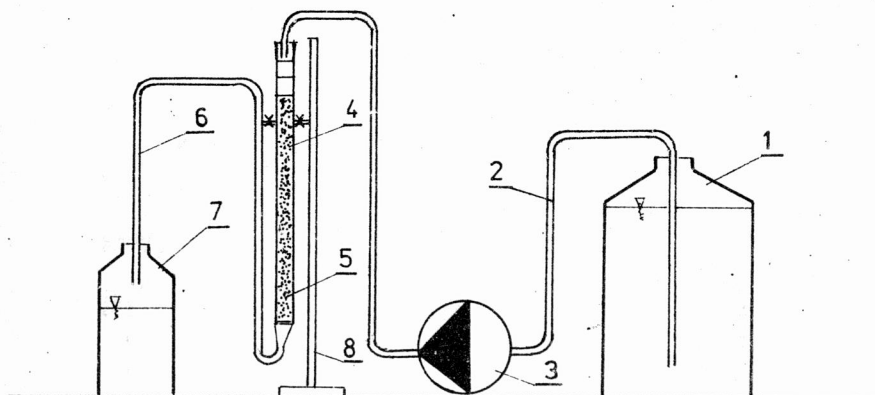


Fig. 1. Diagram of the working apparatus

1 - wastewater container, 2 - rubber tube, 3 - peristaltic pump, 4 - glass column, 5 - ion exchange bed, 6 - rubber tube, 7 - fractional receiver, 8 - tripod

from the columns was directed to the fractional receivers. The fractions collected were analyzed spectrophotometrically.

The second experimental series was carried out for lead according to the procedure described above.

#### 4. RESULTS AND DISCUSSION

The experiments comprised three stages. In the first one, the solutions were of constant concentration of cadmium ( $10 \text{ mg/dm}^3$ ) and lead ( $10 \text{ mg/dm}^3$ ) which were in 150% stoichiometric proportion to EDTA. The solutions were passed through the resin columns of three different bed depths (30 cm, 40 cm and 60 cm). The experiment defined the influence of bed depths upon sorption process of complexing cadmium and lead ions on Amberlite IRA 402. The experimental results are shown in figs. 2 and 3. In the case of cadmium, the bed capacity was exhausted after passing 100, 130, and  $170 \text{ dm}^3$  of effluent through the column of the respective 30, 40, and 60 cm bed depth. In the case of lead, the beds of the same depths were exhausted after passing 74, 98, and  $170 \text{ cm}^3$  of effluent. The best results were obtained at the highest value of bed depth.

The second experimental stage was similar to the first, but the initial concentrations of the working solutions were  $100 \text{ mg/dm}^3$  for both cadmium and lead. In each case, 150% stoichio-

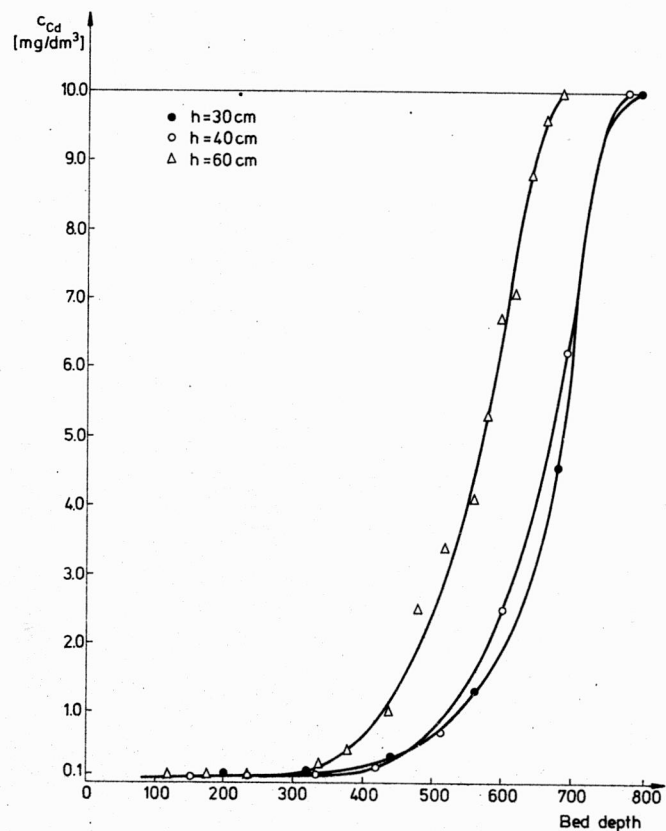


Fig. 2. Characteristic influence of bed depth on sorption of complexed cadmium ions on resin of strong base, type Amberlite IRA 402. Initial concentration  $10\text{ mg Cd/dm}^3$  and 150% stoichiometric proportion of EDTA. Flow rate  $14\text{ m}^3/\text{h} \cdot \text{m}^2$

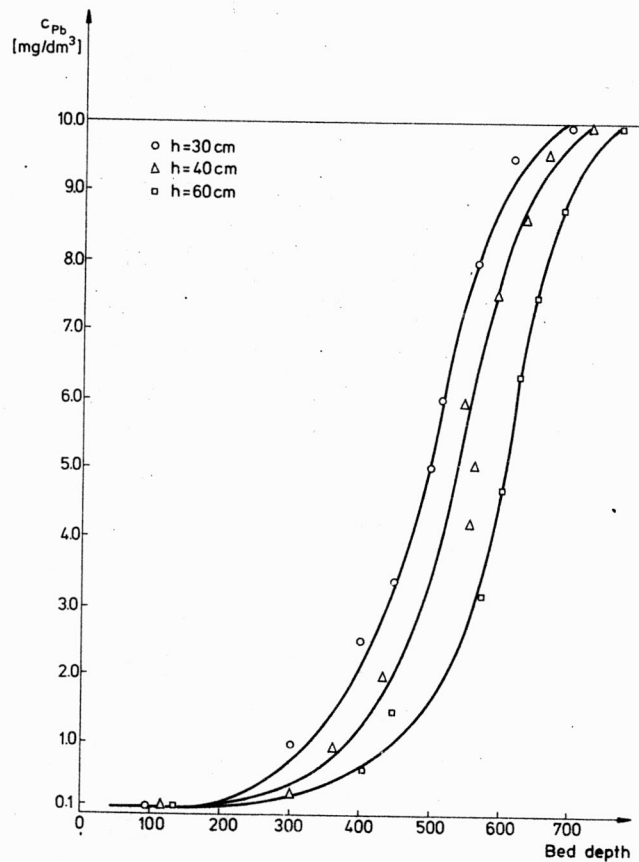


Fig. 3. Characteristic influence of bed depth on sorption of complexed lead ions on resin of strong base, type Amberlite IRA 402. Initial concentration  $10\text{ mg Pb/dm}^3$  and 150% stoichiometric proportion of EDTA. Flow rate  $14\text{ m}^3/\text{h} \cdot \text{m}^2$

metric proportions of EDTA were used and a uniform flow rate of  $14 \text{ m}^3/\text{h} \cdot \text{m}^2$ . At the bed depths of 30, 40, and 60 cm, the first fractions analyzed showed high concentrations of cadmium in the effluent, i.e., 11, 58, and  $0.34 \text{ mg}/\text{dm}^3$ , respectively. In such a situation, it was difficult to determine exactly the breakthrough point from the graph. For the value of  $0.05 \text{ mg Cd}/\text{dm}^3$ , the resin capacity was exhausted after passing 40, 40, and  $75 \text{ dm}^3$  of effluent through the beds of respective depths (fig. 4). In the case of lead, the situation gets better. The lead concentrations in the fractions analyzed increased progressively with the breakthrough points which were achieved after passing 10, 20, and  $40 \text{ dm}^3$  of effluent through the 30, 40, and 60 cm bed depths, respectively. The resin capacities were exhausted after passing 50, 58, and  $84 \text{ dm}^3$  of effluent, respectively (fig. 5).

In the third experimental stage, the influence of EDTA dosages on the sorption of complexing cadmium and lead ions on Amberlite IRA 402 is determined. To this end, three columns of uniform bed depths (60 cm) were used for both cadmium and lead. Solutions of constant concentration ( $10 \text{ mg}/\text{dm}^3$ ) for cadmium and lead which were in different stoichiometric proportions (100%, 110%, and 120%) to EDTA were used. For cadmium, the breakthrough points were reached after passing 40, 55, and  $55 \text{ dm}^3$  of effluent through the beds, the latter being exhausted after passing 160, 165, and  $170 \text{ dm}^3$  of effluent at 120, 110, and 100% EDTA proportions, respectively. In the case of lead, the breakthrough points were reached after passing 85, 95, and  $95 \text{ dm}^3$  of effluent through the beds, the latter being exhausted after passing 165, 180, and  $185 \text{ dm}^3$  of effluent at 120, 110, and 100% EDTA proportions.

The results proved that 100% proportion of EDTA was more advantageous than others because such a proportion guaranteed the highest exchange capacities for both cadmium and lead (figs. 6 and 7).

## 5. CONCLUSIONS

Though the research work is still going on, the results of the experiment done so far were evaluated and the following conclusions drawn:

1. From the calculations, it is seen that bed depth has outstanding influence on ion exchange processes and the most recommended bed depth is 60 cm.
2. The curve shapes depend on the column geometry, hence the higher the bed depth, the more vertical the curves are.
3. At laboratory scale experiments, in which concentrations do not exceed  $100 \text{ mg}/\text{dm}^3$ , it is possible to use only the columns of 30–60 cm in height. For concentrations above  $100 \text{ mg}/\text{dm}^3$ , for effective use, the columns higher than 60 cm should be recommended because the lower ones are exhausted almost immediately without a reasonable effect.
4. The calculation proved that the 100% stoichiometric proportion of EDTA ensures the highest exchange capacity, therefore it is the most effective.

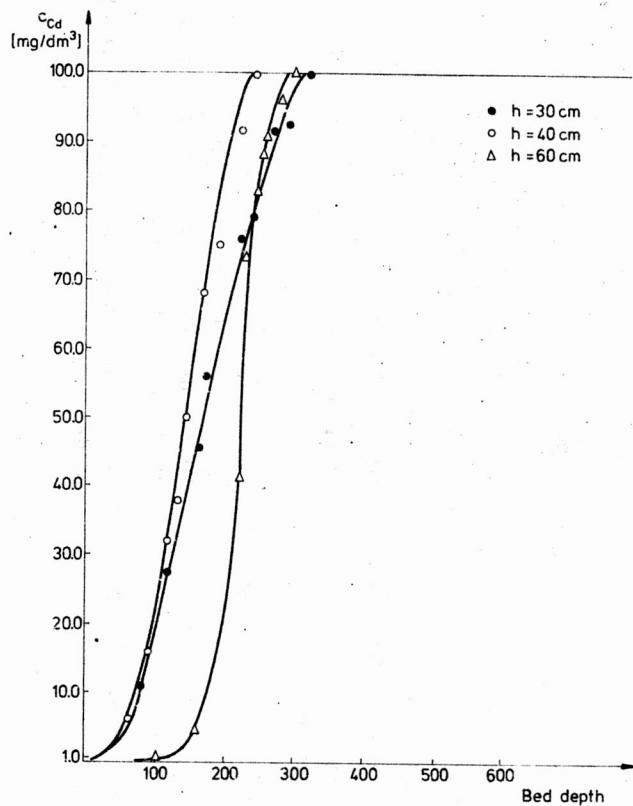


Fig. 4. Characteristic influence of bed depth on sorption of complexed cadmium ions on resin of strong base, type Amberlite IRA 402. Initial concentration  $100 \text{ mg Cd/dm}^3$  and 150% stoichiometric proportion of EDTA. Flow rate  $14 \text{ m}^3/\text{h} \cdot \text{m}^2$

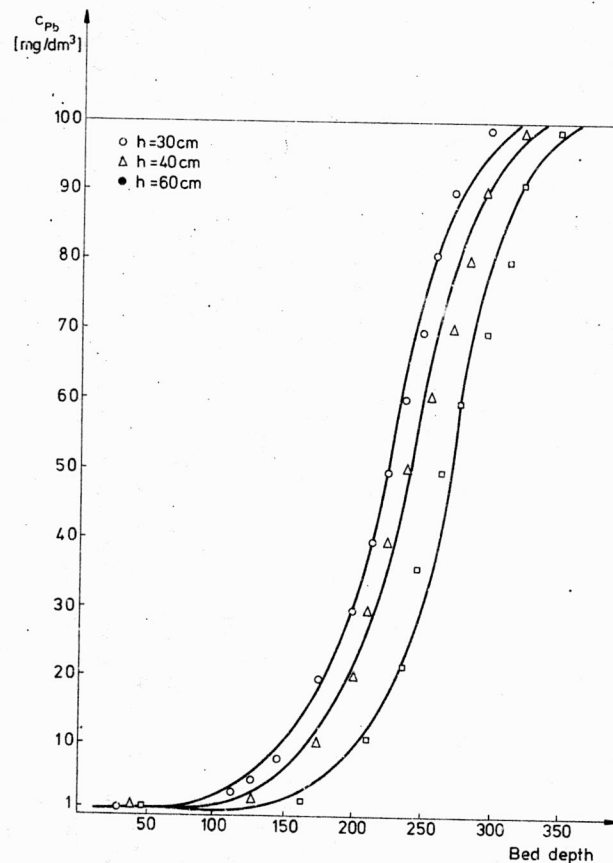


Fig. 5. Characteristic influence of bed depth on sorption of complexed lead ions on resin of strong base, type Amberlite IRA 402. Initial concentration  $100 \text{ mg Pb/dm}^3$  and 150% stoichiometric proportion of EDTA. Flow rate  $14 \text{ m}^3/\text{h} \cdot \text{m}^2$

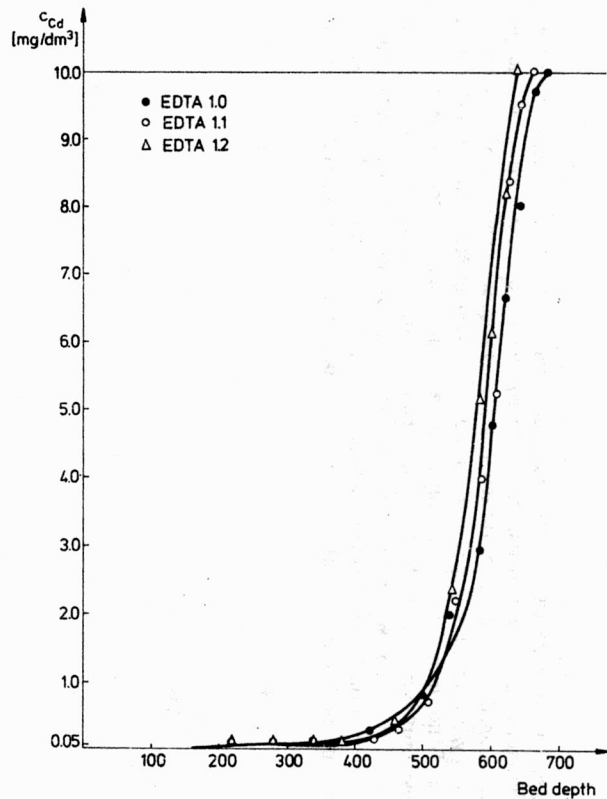


Fig. 6. Characteristic influence of EDTA doses on sorption of complexed cadmium ions on resin of strong base, type Amberlite IRA 402. Initial concentration 10  $\text{mg Cd/dm}^3$  and stoichiometric proportions of 100%, 110%, and 120% EDTA. Flow rate 14  $\text{m}^3/\text{h} \cdot \text{m}^2$

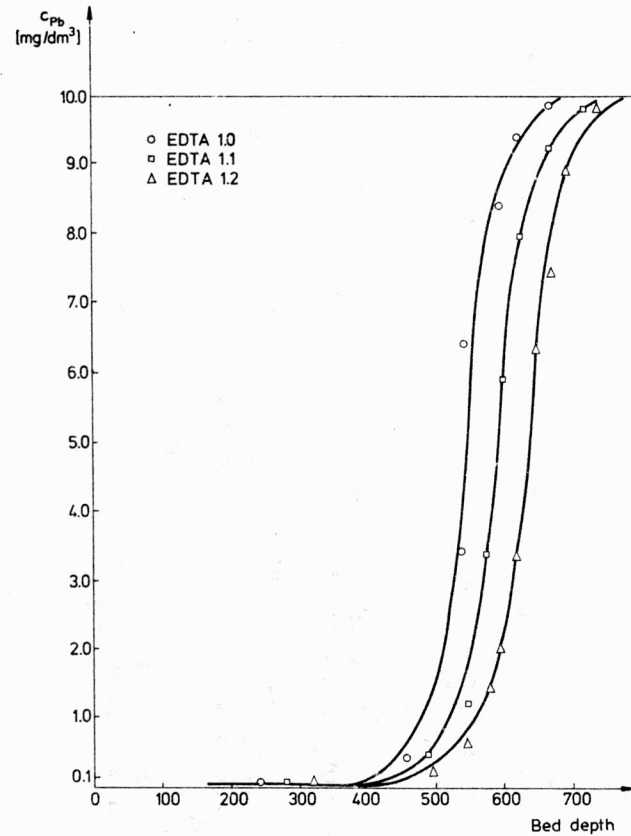


Fig. 7. Characteristic influence of EDTA doses on sorption of complexed lead ions on resin of strong base, type Amberlite IRA 402. Initial concentration 10  $\text{mg Pb/dm}^3$  and stoichiometric proportions of 100%, 110%, and 120% EDTA. Flow rate 14  $\text{m}^3/\text{h} \cdot \text{m}^2$

## REFERENCES

- [1] CHEREMISINOFF P. N., HABIB Y. H., *A plenary account for water pollution*, Water and Sewage Works, part 1, 1972, pp. 73-74.
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USUWANIE METALI TOKSYCZNYCH Z WODY PITNEJ  
PRZEZ ZASTOSOWANIE ICH KOMPLEKSOWANIA Z EDTA ORAZ ŻYWICY ANIONITOWEJ

W wielu częściach świata istnieją zasoby wody skażonej metalami toksycznymi. Zastosowanie konwencjonalnych metod usuwania tego rodzaju zanieczyszczeń nie zmniejsza ich stężenia do dopuszczalnego poziomu. Chociaż dzięki wymianie jonowej możliwe jest uzyskanie wymaganej jakości wody, proces ten jest kosztowny, ponieważ z powodu obecności pospolitych jonów trudno jest otrzymać wymaganą wartość współczynnika selektywności jonów metali toksycznych. Ostatnio podjęto badania, które miały doprowadzić do wyeliminowania tej trudności. W ich trakcie okazało się, że dzięki utworzeniu kompleksu EDTA z pewnymi jonami metali toksycznych wartość ich współczynnika selektywności może być wyższa niż ta jonów pospolitych. W pracy przedyskutowano szczegółowo układ selektywnego usuwania ołowiu i kadmu z wody pitnej.

УДАЛЕНИЕ ТОКСИЧЕСКИХ МЕТАЛЛОВ ИЗ ПИТЬЕВОЙ ВОДЫ  
ПОСРЕДСТВОМ ПРИМЕНЕНИЯ ИХ КОМПЛЕКСООБРАЗОВАНИЯ ИЗ EDTA,  
А ТАКЖЕ ИЗ АНИОНИТНОЙ СМОЛЫ

На многих территориях в мире существуют запасы воды, зараженной токсическими металлами. Применение конвенциональных методов удаления этого вида загрязнений не понижает их концентрации до допустимого уровня. Хотя, благодаря ионообмену возможно получение требуемого качества воды, этот процесс является дорогостоящим потому, что из-за наличия обычных ионов трудно получить требуемое значение коэффициента селективности ионов токсических металлов. В последнее время предприняты исследования, которые должны были привести к устранению этой трудности. По ходу исследований оказалось, что благодаря образованию комплекса EDTA с некоторыми ионами токсических металлов значение их коэффициента селективности может быть выше, чем значение коэффициента селективности обычных ионов. В настоящей работе подробно обсуждена система селективного удаления свинца и кадмия из питьевой воды.